AN ESSAY ON

The Foetal Circulation.

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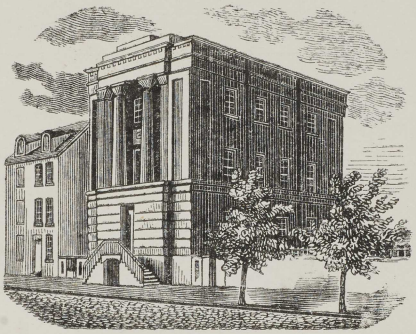

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The Foetal Circulation.

Although a true idea of the foetal circulation is of but little practical importance, either to the Anatomist or physiologist, yet it is a subject that always has and ever must interest both. Like many other subjects connected with the human organism, doubt and uncertainty will cling to all hypotheses the mind of man can form concerning it. True, new light is continually illumining the mind and making clear many things connected with anatomy & physiology that were, before, shrouded in darkness & doubt. So long, however, as we are unable to behold the working of the various organs of the foetal circulatory apparatus, when influenced by the all important principle - life -

and are forced to judge of their true offices from the information derived of the lifeless foetus, we can expect merely to obtain an approximation to the truth, and to acquire this, alone, by means of much research and labor.

In the following paper the circulation of the blood within the foetus is the point to be considered. Concerning the object of the placental circulation, there is, at present, but little difference of opinion — all agreeing that it is for the purification, or, in a certain sense the aeration of the foetal blood. As to the manner this is effected, opinions are various and conflicting. On the other hand, the course of the blood within the foetus and the changes that take place there, have been the source of much discussion and even at

the present day, the medical fraternity are divided in opinion on these points.

The plan we shall endeavour to carry out in the treatment of this subject is—

1st To give a synopsis of the theory of the foetal circulation, as held by many, if not most, medical men of the present day

Secondly— To give, in a few words, a second theory held by some of our modern physiologist, which, in part at least, is a revival of views, advanced by men of former days

Thirdly— To compare the two theories, and state briefly the arguments that are advanced to sustain each.

First— The old & commonly received theory is, that the blood is brought from the placenta by the umbilical vein,

which, together with the two umbilical arteries, enters the abdominal portion of the foetus at the umbilicus. The vein passes from the umbilicus to the under side of the liver, where it divides into three veins that convey the blood to the liver — two veins going to the left lobe and one to the right — and a fourth —, the ductus venosus, that carries the blood directly into the vena cava inferior, or opens into the hepatic vein.

It is assumed by some of the advocates of this theory, that the larger part of the placental blood passes into the vena cava inf. through the ductus venosus — only a small portion going to the liver. Others, on the contrary, allow that the liver is very plentifully supplied with placental blood and, hence, arises its great size.

The placental blood, having mingled with the venous blood, that has been collected from the

abdominal and inferior portions of the foetus is the vena cava inf., flows through this vein to the right auricle, where it is alleged, that, by means of the Eustachian valve at the mouth of the vein, it is directed in a continuous stream across the right auricle into the left, through the foramen ovale. At the same time, the venous blood, that has been collected from the superior portions of the foetus by the vena cava superior, passes into the right ventricle through the right auricle - not mixing, or very slightly at least, with the mixed placental blood from the vena cava inferior. The placental blood from the left auricle is forced into the left ventricle, and, thence, into the aorta, and conveyed to the upper portions of the foetus by its respective arteries. The venous blood in the right ventricle is forced into the pulmonary artery. A part goes

to the lungs — the rest — being the greater amount, as assumed — passes directly into the descending aorta through the ductus arteriosus, and returns to the placenta through the umbilical arteries.

The great object of this theory is to account for the earlier development of the superior portions of the foetus, as is claimed to be the case, — by securing a purer blood for the nourishment of these parts than for the other portions of the new being.

Secondly. According to the second theory, the placental blood is brought to the foetus and conveyed to the under side of the liver by the umbilical vein. It, here, divides into the three veins of the liver and the ductus venosus. The veins of the liver are assumed to receive as much, if not more blood

than the ductus venosus. This, after nourishing the liver, passes into the vena cava inferior, as venous blood, where it mingles with the pure placental blood that has passed through the ductus and the venous blood from the abdomen & the inferior portions of the foetus. It, thence, flows into the right auricle, where it meets the venous blood from the vena cava superior. A portion of this mixed blood is forced into the left ventricle, the aorta & its respective arteries; & the remainder to the right ventricle, pulmonary artery, lungs, & ductus arteriosus. The ductus is supposed to act merely as a waste pipe for that portion of the blood the lungs do not need. The greater part is assumed to pass through the lungs, which, having nourished them, is returned to the left auricle as venous blood. This theory, as will be seen, as

we proceed with our subject, taking the veins arteries, valves, muscular action and the light analogy throws on the subject; and comes to the conclusion that not merely the lower portion of the foetus, but the whole foetus receives for its nourishment a mixed blood - in fact, a blood in which the venous greatly preponderates.

Thirdly - In order to treat our third point as clearly as possible, we will follow the placental blood in its course, after it enters the foetus - notice the various changes each of these theories assume it passes through - observe their agreements and disagreements, and briefly state the arguments used in behalf of each, when we find they disagree.

We shall, however, dwell more at length on the arguments in favor of the second Theory,

as those employed to support the first may be found in almost any anatomy or physiology in use at the present day.

Up to the division of the umbilical vein into the veins that go to the liver and the ductus venosus, the theories coincide. Here however we find a disagreement between the second theory and some of the advocates of the first, who claim that nearly all of the placental blood passes directly into the vena cava inferior through the ductus venosus - the liver merely receiving enough for its own nourishment. The second theory, as well as some of the advocates of the first, on the other hand, asserts that one half, if not more, goes to the liver, and is returned to the vena cava inf. as venous blood.

In support of the first view, it is

argued, that, on injecting the dead foetus, the
ductus is found to be a very little smaller
than the umbilical vein, and even larger
than the vena cava inf. The veins, that are
sent to the liver from the umbilical vein,
are found to be extremely small in comparison
with the ductus. Hence, it is inferred, that
the veins & ductus bear a similar proportion
to each other in the live foetus.

In opposition to this view, it is contended
that we cannot judge of the true action of
veins and organs, when incited to activity
by that powerful stimulus-life - by mere
injecting in a lifeless foetus.

Is it to be supposed, that an injection
will pass through the smaller veins of an
organ, so compact in its structure as the liver,
when uninfluenced by life, as readily as it

would through the ductus lying comparatively free and unconfined? Would it not, even if it found a ready passage through the lungs be greatly retarded in its flow through the smaller veins, and, in consequence of this, would not the easiest and quickest course to the vena cava inf. be through the ductus, which we should expect to find greatly distended, as is really the case.

In order to obtain the comparative size of the veins &c, another course may be and has been adopted — one not liable to so serious objections, and one that seems to sustain the second theory; and is used as an argument in its favor. The vessels that are to be compared, should be dissected out carefully, and, when entirely freed from their contents, laid on a plane surface, and, thus, their relative size

obtained by comparing vein with vein.

This has been done with the following result, "In a foetus of about eight and a" "half months, the ductus venosus was found to" "have a semi-circumference of less than 3/100 of an" "inch and the umbilical vein of 13/100. In a" "foetus of six months the former had a semi-" "circumference of 4/100 of an inch and the latter of" "12/100 - the proportion being about one to three in both" "cases. Each of the hepatic veins is quite as" "large as the ductus venosus; and these with" "the latter carry into the vena cava of all the" "blood brought from the placenta by the umbilical" "vein and from the formative branch of the vena" "portae."

Hence it is argued, that the hepatic vein convey as much, if not more, placental blood to the liver, as the ductus does to the vena cava

inferior. If the blood goes to the liver, in order to nourish the organ, analogy teaches that it is returned to the vena cava inf. as venous blood.

At this point it is argued by some of the advocates of the first theory that the liver, as well as the placenta, acts as a depurating organ. In so far as it secretes bile, it undoubtedly eliminates certain crude materials from the blood, still this process does not render the blood arterial. In the adult it is well known, that the venous blood from the abdominal organs of the abdomen is conveyed by the vena portae to the liver where bile is secreted for the purpose of aiding digestion. In the foetus both this source for obtaining the constituents of bile and the principal object for which it is

secreted fail

In opposition to the view advanced by some (and with a good deal of plausability) it must be acknowledged) that the placental blood in passing through the liver is freed from an excess of carbon & hydrogen and thus rendered purer, the following objections are offered by the friends of the second theory.

First It is unreasonable to suppose, that the placental blood would have an excess of carbon & hydrogen, sufficient to be of use in the formation of any amount of bile.

Secondly If this is the principle object of its passage through the liver, we should expect to find bile secreted earlier in foetal life than the fifth month, and a greater amount of it in the meconium, than is the case according to the statement of certain physiologist.

Thirdly. Considering the great size of the liver and the amount of blood that must necessarily be used in nourishing the same, and which analogy teaches is returned to the vena cava inf. as venous blood, it is thought the blood thus rendered impure must far exceed all that is purified by the liver in the secretion of bile

Fourthly. If, in the liver of the adult, it is not claimed, that the venous blood, derived from the vena portae, is arterialized by the elimination of carbon & hydrogen, analogy at least would not justify physiologists in assigning an office of the kind to the foetal liver.

The true cause of the great size of the foetal liver is still a mystery - one not easily solved with our present physiological

knowledge. Many a varied theory have been proposed by different investigators. A consideration of these, however, would make this article of too great length, so we will pass on in our investigation.

Thus we find according to some of the advocates of the first theory, that the greater part of the placental blood passes into the vena cava inf. through the ductus venosus, where it mingles with venous blood from the lower extremities and a small amount of venous blood sent from the liver. On the other hand, the second theory claims that only a small amount of placental blood passes through the ductus, and, there, unites with the venous from the lower portion of the foetus and a large amount from the liver — thus making the venous blood to preponderate greatly.

The blood, now pursuing its course through the vena cava inf. to the right auricle of the heart, when we find the two theories differ. The first asserts, that the blood from the vena cava inf passes directly across the right into the left auricle through the foramen ovale — assuming, that the peculiar office of the Eustachian valve at the mouth of the vein is to direct the current to the foramen. — It, also, declares that the venous blood from the vena cava superior flows directly into the right ventricle through the right-auricle, and that little, or no, intermixture of these two streams takes place.

Here, as in case of the veins of the liver and ductus venosus, this vein derives its great support from experiments made on the lifeless body. It has found in a

case of a foetus of seven months, when an injection of a certain colour was thrown into the vena cava superior, and one of a different colour in the vena cava inf., that the former passed into the right auricle and ventricle, pulmonary artery, ductus arteriosus & descending aorta; and the latter through the right auricle into the left auricle & ventricle, the aorta & arch, & the arteries of the superior portions of the foetus, with no mingling of the two streams in the auricles.

It is inferred, that the normal actions of the two currents of blood in the live foetus is similar.

To this conclusion, however, the advocates of the second theory dissent. For, if this does appear reasonable, when the organ is powerless, with no activity of its own, it does not, when endowed with life and the powers consequent thereto.

Is it to be supposed that the heart, which not only possesses the power of suction but also of propulsion — whose apartments are continually dilating or contracting in consequence of a power inherent in it; when under the influence of life; is it to be supposed, we would repeat, that this organ would permit two streams of blood to pass through the same cavity, at the same time, without an intermixture of the same? Does it, from the very nature of the case, seem possible?

The peculiar office, claimed for the Eustachian valve by the first theory, is denied by the second. There are two objections to this view.

The first, that the position of the valve is not the one best adapted for directing the current of the vena cava inf. through the foramen ovale.

"Its situation, being on the anterior portion of
"the vein and extending thence to the posterior
"inferior border of the foramen, and sometimes to
"the middle of the posterior border, does not
"seem so suitable for obtaining the end designed
"as if it extended anteriorly posteriorly with the
"fixed portion of the valve bounding the foramen."

The second objection is, that, if the true office of the valve is to direct the placental blood into the left auricle, so that the superior portion of the foetus may be first developed, we should anticipate, that the valve would increase in power, as the foetus developes, or, at least it would not decrease. To the contrary, we find, that, about the seventh month, it begins to atrophy and this continues until birth, so that near the close of foetal life, it has little or no power. This fact has led some Physiologist

to infer, that, although the valve may exert some influence, in preventing the current of venous blood from falling too forcibly on that of the vena cava inf.-containing placental blood somewhat impure, still the important function of the valve is to oppose the regurgitation of the blood from the right auricle into the vena cava inf.

The position of the valve, as before stated, is better adapted to the accomplishment of this object - than for the purpose, usually, assigned it. In addition, as the foramen ovale becomes closed by its valve in the groin of the foetus and the Eustachian valve is less & less needed on account of the valve of the foramen relieving a portion of its office, we find the Eustachian valve becomes more and more atrophied and useless.

Hence, according to the second theory, the placental

blood receives an addition of venous blood from the vena cava superior in the auricles, and this mixed blood is sent to both the right and left ventricles.

Leaving the blood in the left ventricle for the present, we will return to the blood in the right ventricle. One theory asserts that it is all venous — the other that it consists of placental and venous mixed, not quite so pure as is that which has passed into the left ventricle; for the Eustachian valve may have some influence in directing the current of the vena cava inf. into the left auricle — still it is not entirely venous. This blood, now, enters the pulmonary artery. Here the theories are at variance. The one assuming that only a small portion goes to the lungs, the greater portion passing directly into the descending aorta through

the ductus arteriosus.

The other claims, that the lungs receive quite a large amount of blood - the residue being transmitted to the aorta by the ductus.

Here, as with the liver, the first theory receives its chief support from injections. The ductus arteriosus is found to be greatly distended, exceeding in size the arteries carrying the blood to the lungs, and even larger than the pulmonary artery before its division, and nearly, if not quite, as large as the aorta. The argument, deduced from these facts, is met by its opposers with the same train of reasoning, as in the case of the excessive enlargement of the ductus venosus.

In advocacy of the second theory, if the same course is taken with the arteries, as was followed with the veins of the liver, it is found that the ductus arteriosus bears the same proportion

(one to three) to the pulmonary artery before its division, that the ductus venosus does to the umbilical vein. The ductus arteriosus is, also, found to be a little smaller than either of the pulmonary arteries sent to the lungs, after the division of the main pulmonary artery. This, being the relative size of the arteries & the ductus, it is argued, accordingly, that the lungs receive a much larger quantity of blood than is allowed by the first theory, and it is even maintained that they receive as much, if not more, as passes through the ductus into the aorta. As there is no depurating or aerating power claimed for the foetal lungs, it must go, then, for their nourishment and, consequently, be returned to the left auricle as venous blood. Thus the blood, to be sent to the upper extremities, as well as the lower, will

be rendered more impure by an additional amount of venous blood from the lungs.

A consideration of the blood in the left ventricle, alone, remains. The first theory has filled it with a comparatively pure placental blood which is sent through the aorta and the arteries of the superior portion of the body; they, it is supposed, affording an explanation of the earlier development of this portion of the foetus.

The second theory claims that it contains a mixed blood, perhaps a little purer than what has been sent to the right ventricle from the action of the Eustachian valve.

According to both theories after the blood has accomplished all the good it can in the new being, it is sent from the foetus to the placenta through the two umbilical arteries, to be rendered again suitable for its proper function.

Now arises the question, how is the development of the superior portion of the foetus, in advance of the lower portion, to be explained by the second theory?

As has been seen, to give an explanation of this phenomenon is the all important point - the great object of the first.

In answer to this question, it is contended, that it is not true, that this early development pertains merely to those parts that are supplied according to the first theory with comparatively pure blood from the left ventricle. The abdominal viscera, although receiving, as asserted, venous blood alone, excepting a little that may not be taken up by the arteries of the head &c. are evidently developed as early, and called into action, after birth, as soon as any other organ of

the body. It is, also, a well known fact, that certain bones are developed much sooner than others, when as far as position in the body is concerned, one appears as formally situated for development as the other. If we turn to Comparative Physiology, we observe, that in the young of quadrupeds the body appears to be equally developed in the most of its parts, and that at birth the posterior extremities are as active and endowed with as much strength as the anterior.

Why is there this difference between the human foetus and that of the quadruped, when their circulatory systems are very similar?

It is as difficult to explain these facts according to the first theory, as it is for the second to answer the question proposed.

When the first can explain these

facts satisfactorily, then, perhaps, the second may give the answer required.

Undoubtedly, with our present knowledge of Physiology, both theories must plead ignorance for their defence.

Comparative Physiology furnishes us with a fact, that seems to sustain the second theory. In tracing the growth and changes of the new being, from its embryotic state up to its birth, we find that it undergoes various transformations. It is observed "that as "the embryo of each higher animal passes rapidly" "through the forms of the animals inferior to it," "in order to obtain its maturity and specific rank" "of being, that of man is transitively the compendium" "of all; not, indeed, without a difference, since, in" "each instance, the changing form of the Embryo" "bears the impress of the transitional and"

"incomplete character, while it ever preserves"
"the promise and prophecy of the being into"
"which it is to be finally evolved".

This holds good, not merely, as respects the whole fœtus; but we also, find that its various organs, at different stages of growth, resemble corresponding organs in fishes, reptiles &c. The circulatory apparatus is no exception to this rule. The fœtal heart having passed through certain changes, at length reaches that stage of development, when it resembles, in a measure at least, the reptile heart. There is as great similarity in the two, as could be expected of organs, where one is in a "transitional state", and is, soon to be called upon to perform more important duties, and to display a more intricate construction.

The reptile heart consists of two auricles and a ventricle. One of the auricles receives an impure

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blood — the other a purer blood. The auricles, then, force the blood into the ventricle, where a mixing of the two takes place, and the reptile receives a mixed blood to nourish it. If therefore distinguished Physiologists have been led to claim a similarity between the foetal and reptile heart, because each possesses only three apartments; certainly the advocates of the second theory have a right to claim, that the fact, that the true function of the reptile heart is to prepare and send a mixed blood through the reptile organism, is confirmatory of the ground taken by them concerning the action of the foetal heart, and the character of the blood sent to all portions of the foetus. For, in this way, not only similarity of construction, but, also, of function is proved.

We have endeavored, in the preceding pages, to do justice to both theories,

and to state fairly the arguments advanced in behalf of each.

A satisfactory explanation of the phenomenon of the foetal circulation, as a whole, cannot be derived from either, alone. Each seems to have favorable points, that the other does not possess. One theory can explain certain facts that the other cannot, and vice versa.

The question of the foetal circulation is, by no means, a practical one. It matters not in what way it may be decided, whether for or against this or that theory. It is of no importance, whether the head receives pure or impure blood, or how or the whole process of utero gestation is carried on by means of laws, that are as unchangeable as the Being, who created them. We may contend for this or that theory, yet of what avail, it

may be asked? None practically! Still it is a question of deep, yea! we may say the deepest interest to all reflecting minds. For on a careful examination of the whole phenomenon, it is found to be one truly wonderful. No one can endeavour to fathom its mystery without being benefitted by the effort. For, as we behold its beautiful and wonderful mechanism, and observe the harmonious action of its varying organs; all tending to nourish and unfold an immortal being for this order life - for its joys & sorrows, there are not many whose senses are so obtuse, that they are not led from the creature to the Creator - whose faculty of adoration so feeble, that they are not brought into nearer communion with the great Being who ~~xxx~~ planned the great work of creation, and who surpassed all preceding works of his hand, in the creation of immortal man. God, by making

us reasoning beings has given us the power,
in fact has enjoined upon us as a duty
to search into the wonders he has
so profusely scattered around us; and thus
many things that now seem dark & mysterious
will be clearly understood in all their bearings.
as man becomes better acquainted with
the fixed laws that govern his own
being & the great Universe around him.